(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 494 785 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 92300193.7

(22) Date of filing: 09.01.92

(51) Int. Cl.^{5}: F25D 21/06, F25B 47/02

(30) Priority: 11.01.91 GB 9100622

(43) Date of publication of application: 15.07.92 Bulletin 92/29

(84) Designated Contracting States: AT BE CH DE DK ES FR GB GR IT LI LU MC NL PT SE

(71) Applicant: Morris, Michael
62 Northumberland Terrace
Wallsend, Tyne & Wear, NE28 6QG (GB)

(71) Applicant: Proud, Frank David
18 Greenside Crescent
Denton Burn, Newcastle upon Tyne, NE15 7HR (GB)

(72) Inventor: Morris, Michael
62 Northumberland Terrace
Wallsend, Tyne & Wear, NE28 6QG (GB)
Inventor: Proud, Frank David
18 Greenside Crescent
Denton Burn, Newcastle upon Tyne, NE15 7HR (GB)

(74) Representative: Sanderson, Michael John et al
MEWBURN ELLIS & CO 2/3 Cursitor Street
London EC4A 1BQ (GB)

(54) Temperature control system for refrigerator.

(57) A temperature control system for controlling the defrosting of a refrigerator includes at least one semiconductor device (S1,S2) for sensing the temperature within the refrigerator, and an electronic control unit (14) to which the or each temperature sensing device (S1,S2) is connected such that, when the temperature sensed by a device (S1) reaches a predetermined minimum value, a cycle for defrosting the evaporator unit (4) of the refrigerator is initiated, and, when the temperature sensed by the device (S1) reaches a predetermined maximum value, the defrost cycle is stopped.

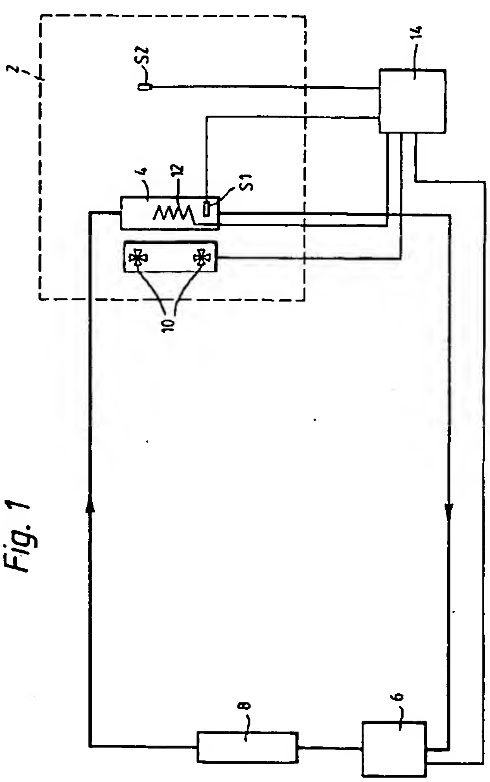


Fig. 1

EP 0 494 785 A1

Jouve, 18, rue Saint-Denis, 75001 PARIS

This invention relates to a temperature control system for a refrigerator, and more particularly to such a system for controlling the defrosting of a refrigerator.

The evaporator coil of a conventional compression refrigerator requires periodic defrosting to eliminate the build-up of ice thereon.

Heretofore this has usually been achieved by incorporating within the refrigerator control unit a timer whereby the cooling system is switched off at preset intervals for predetermined lengths of time - for example every 2 hours for 7 minutes.

Although the preset intervals and the predetermined lengths of time can be varied, such an arrangement can still result in undesirable and unnecessary rises in cabinet temperature, as well as excess power consumption.

It would be desirable to be able to provide a system for controlling the defrosting of a refrigerator which eliminated the aforementioned disadvantages of the current arrangements.

According to the present invention there is provided, for a refrigerator having a cabinet and a cooling circuit including an evaporator unit, a compressor unit and a condenser, a temperature control system comprising at least one temperature sensing device for location within the refrigerator, and an electronic control unit to which the or each temperature sensing device is connected in such a manner that, when the temperature sensed by a device reaches a predetermined minimum value, a cycle for defrosting the evaporator unit is initiated, and, when the temperature sensed by said device reaches a predetermined maximum value, the defrost cycle is stopped.

Thus it will be appreciated that such a system provides defrost on demand - i.e. only when it is necessary - and terminates the defrost cycle as soon as defrosting has been completed in accordance with the predetermined settings thereby preventing undue temperature rises in the cabinet and avoiding undue power consumption by the refrigerator.

In one embodiment of the invention, the defrost cycle comprises switching off the compressor unit at said predetermined minimum temperature and switching the compressor unit back on at said predetermined maximum temperature.

In an alternative embodiment of the invention, the defrost cycle comprises eliminating the condenser from the coolant circuit whereby the vaporised refrigerant flows through the evaporator unit to effect defrosting of the evaporator unit.

In a preferred temperature control system there are at least two temperature sensing devices, one located at or adjacent the evaporator unit and connected to the electronic control unit to control the defrost cycle, and another located in the cabinet and connected to the control unit to control the temperature in the cabinet.

The refrigerator may include a fan unit for circulating air within the cabinet and through the evaporator unit, and heating means for assisting defrosting of the evaporator unit, in which case, on initiation of the defrost cycle, the fan unit is switched off and the heating means is switched on, and, on termination of the defrost cycle, the heating means is switched off and the fan unit is switched on.

Conveniently the control system includes means for delaying switching on of the fan unit after termination of the defrost cycle until the temperature sensed by the device at or adjacent the evaporator unit has fallen to a value below said predetermined maximum value.

Preferably the or each temperature sensing device comprises one or more semi-conductor devices, for example diodes, while the electronic control unit may comprise a microprocessor together with separate RAM and ROM peripherals, or, alternatively, a microcontroller with inbuilt RAM and ROM peripherals.

Conveniently the control unit includes means, preferably potentiometers, for adjusting:

a) the temperature within the cabinet;

b) the predetermined minimum temperature of the evaporator unit at which the defrost cycle is initiated;

c) the predetermined maximum temperature at the. evaporator unit at which the defrost cycle is stopped;

d) the temperature at which the fan unit is switched on after termination of the defrost cycle.

By way of examples only, embodiments of the invention will now be described in greater detail with reference to the accompanying drawings of which

Figs. 1 and 2 show a temperature control system according to the invention as applied to two alternative refrigerators, and

Fig. 3 is a schematic block diagram of a temperature control system according to the invention.

Referring to Fig. 1, there is shown a first refrigerator comprising a cabinet 2, an evaporator unit 4, which may be of the coil or plate type, a compressor 6 and a condenser 8 interconnected in conventional manner.

Evaporator fans 10 are positioned adjacent the evaporator unit 4 to circulate air within the cabinet 2 and around the evaporator unit 4, while a heater 12 within the evaporator unit 4 is provided to speed up the defrost process as will be detailed below.

The refrigerator incorporates a defrost temperature control system schematically illustrated in Fig. 3 and including a first temperature sensor S1 located within the evaporator unit 4 and a second temperature sensor S2 located within the cabinet 2. The sensors S1 and S2 comprise semiconductors, conveniently diodes.

The sensors S1 and S2 are each connected in series with an associated resistor such that, on the

application thereto of a voltage, the voltage across each diode is inversely proportional to the temperature of the diode, said voltage typically varying by 2.2 mv/°C.

The semi-conductor sensors S1 and S2 are each connected to a central electronic control unit indicated generally at 14, as are the compressor 6, the fans 10 and the heater 12.

Also connected to the control unit 14 are four user-adjustable potentiometers P1, P2, P3 and P4 which enable the user to set the required parameters of the control system. More particularly, P1 determines the temperature within the cabinet 2, P2 determines the temperature of the evaporator coil 4 at which the defrost begins, P3 determines the temperature of the evaporator coil 4 at which defrost ends, and P4 determines the delay after termination of defrost at which the fans 10 are started up.

The control unit incoporates a microprocessor with separate associated RAM and ROM facilities, or a micro-controller with these facilities inbuilt, together with an analogue to digital conversion facility and a multiplexer.

Under normal conditions within the refrigerator, the compressor 6 is actuated by the control unit 14 in accordance with the setting of potentiometer P1 to maintain the temperature within the cabinet 2 at the desired value, which temperature is monitored by the sensor S2. The fans 10 are operating, the heater 12 is off and the sensor S1 is constantly monitoring the temperature at the evaporator unit 4.

Under the control of a software program, residing in ROM, the microcontroller constantly reads the signals from the sensors S1 and S2 as well as the user settings of the potentiometers P1,P2,P3 and P4 through a multiplexing system and an analogue to digital conversion system whereby decisions can be made as to the control of the associated refrigeration equipment on the basis of the temperatures of the sensors S1 and S2 and the requirements of the user as determined by the potentiometers P1 to P4.

These decisions are implemented by control devices, which may be relays, transistors or the like, under-the control of the unit 14 to operate or otherwise the compressor 6, fans 10 and heater 12.

When the temperature of the evaporator unit 4 as sensed by sensor S1 falls to the minimum value as determined by potentiometer P2, the compressor 6 and fans 10 are switched off and the heater 12 is switched on to initiate the defrost process.

Once the temperature at the evaporator unit 4 has risen to the maximum value as determined by the potentiometer P3, the compressor 6 is switched back on and the heater 12 is switched off, the fans 10 remaining off.

When the temperature of the evaporator unit 4 has fallen to the value determined by the potentiometer P4, the fans 10 are activated. This delay in fan operation serves to prevent any moisture that may be present on the evaporator unit immediately after defrost has been terminated from being blown onto the produce within the cabinet 2.

Integral with the microcontroller is a display driver through which a digital liquid crystal diplay can indicate the temperature in various parts of the equipment. In this respect, provision can be made for one or more additional sensors such as S3 to be mounted in the cabinet 2 and connected to the control unit 14.

Each sensor S1, S2 or S3 may comprise a number of semiconductors connected in series.

The LCD can also be used to indicate faults in the system as well as which parts of the equipment are at any time on or off.

Fig. 2 illustrates an alternative refrigerator to which the control system of the invention has been fitted, components equivalent to those of Fig. 1 being similarly referenced.

Instead of incorporating an electrical heater to speed up defrosting, the embodiment of Fig. 2 utilises reverse-cycle defrosting.

More particularly, the coolant circuit incorporates a solenoid valve 16 connected to the control unit 14 in such a manner that, under normal operating conditions, liquid refigerant flows to the evaporator unit 4, vaporised refrigerant flowing from the evaporator unit 4 back to the condensor unit 6 via the compressor 6, the high pressure vapour condensing in the condenser with consequential emission of heat.

However, once the evaporator unit 4 reaches the minimum temperature determined by potentiometer P2, the solenoid valve 16 is operated by the control unit 14 whereby the flow path of the high pressure vaporised refrigerant by-passes the condenser 8 and continues through the evaporator unit 4 and back to the compressor 6. Thus the passage of the hot gas through the evaporator unit serves to defrost said unit, the role of the evaporator unit being temporarily reversed into that of a condensor until the temperature thereof rises sufficiently to terminate the defrost cycle - the solenoid valve 16 is then re-operated to restore the condenser 8 into the coolant circuit.

Thus there is provided a refrigeiator control system in which defrost is temperature initiated, in that the evaporator unit detects abnormally lower evaporating temperatures caused by the build-up of ice on the coil or plate and initiates defrost by, in the case of Fig. 1, actuating defrost heaters and switching off the condensor (or operating a solenoid fitted in the liquid line between the evaporator unit and the compressor) and, in the case of Fig. 2, establishing reverse cycle defrost.

The defrost is temperature terminated when the evaporator unit sensor reaches the temperature set by the user on the defrost termination potentiometer.

This method of controlling defrost increases cabinet efficiency and reduces power consumption by

omitting unnecessary defrosts.

The use of rotary potentiometers to set the variable parameters means that there is no need for battery back-up in the event of mains power failure, and so allows the system to be adjusted by a person with no prior knowledge of microprocessors or digital techniques.

The operation of the unit depends upon the program resident in ROM, but alterations to this program can readily be made to accommodate special applications such as limited compressor starts, drain delays, maximum defrost duration, reverse cycle defrost, alarm delay after door-opening and the like.

Conveniently, open or short circuit sensor faults are indicated on the LCD, with both the nature of the fault and the sensor to which it applies being displayed.

Defrost can be initiated typically at any temperature between +10°C and -40°C in increments of 0.1°C, allowing use of the system in a wide variety of applications, it being preferred that the sensor S1 is located within the evaporator unit on the air-intake side thereof and remote from the heater.

The control system may further include an alarm which is actuated when the cabinet temperature reaches an abnormally high or low value. More particularly, when the sensor S2 detects such an abnormal temperature, an alarm output is established which triggers a visual and/or audible alarm such as an LED and/or a peizo-electric sounder module.

Means may also be provided in the control system whereby spot temperatures within the refrigerator at given times or average temperatures over short periods of time may be stored in the memory of the microcontroller, this information being capable of being down-loaded for analysis or inspection.

Claims

1. For a refrigerator having a cabinet (2) and a cooling circuit including an evaporator unit (4), a compressor unit (6) and a condensor (8), a temperature control system characterised by at least one temperature sensing device (S1) for location within the refrigerator, and an electric control unit (14) to which the or each temperature sensing device (S1) is connected in such a manner that, when the temperature sensed by a device (S1) reaches a predetermined minimum value, a cycle for defrosting the evaporator unit (4) is initiated, and, when the temperature sensed by said device (S1) reaches a predetermined maximum value, the defrost cycle is stopped.

2. A control system as claimed in claim 1 in which the defrost cycle comprises switching off the compressor unit (6) at said predetermined minimum temperature and switching the compressor unit (6) back on at said predetermined maximum temperature.

3. A control unit as claimed in which the defrost cycle comprises eliminating the condensor (6) from the coolant circuit and passing the vaporised refrigerant through the evaporator unit (4) whereby said evaporator unit (4) is defrosted.

4. A control system as claimed in any one of claims 1 to 3 and including at least two temperature sensing devices (S1,S2), one (S1) located at or adjacent the evaporator unit (4) and connected to the electronic control unit (14) to control the defrost cycle, and another (S2) located in the cabinet (2) and connected to the control unit (14) to control the temperature in the cabinet (2).

5. A control system as claimed in claim 1 or claim 2 for a refrigerator which includes a fan unit (10) for circulating air within the cabinet (2) and heating means (12) for assisting defrosting of the evaporator unit (4), and so arranged that, on initiation of the defrost cycle, the fan unit (10) is switched off and the heating means (12) is switched on, and, on termination of the defrost cycle, the heating means (12) is switched off and the fan unit (10) is switched on.

6. A control system as claimed in claim 5 and including means for delaying switching on of the fan unit (10) after termination of the defrost cycle until the temperature sensed by a device (S1) at or adjacent the evaporator unit (4) has fallen to a value below said predetermined maximum value.

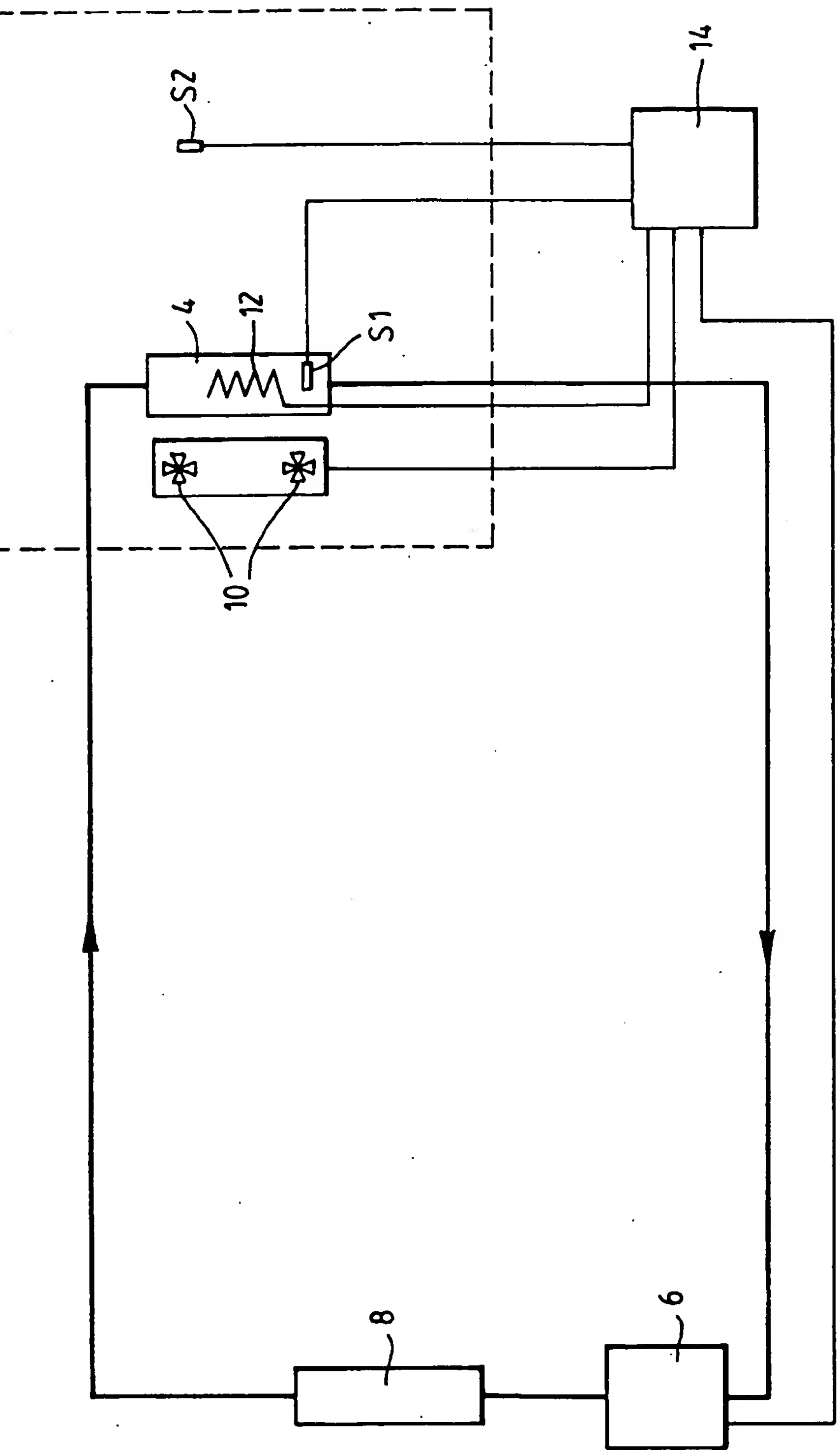
7. A control system as claimed in any one of claims 1 to 6 in which the or each temperature sensing device (S1,S2) comprises one or more semi-conductor devices such as diodes.

8. A control system as claimed in claim 7 in which the electronic control unit comprises either a microprocessor together with separate RAM and ROM peripherals, or a microcontroller with inbuilt RAM and ROM facilities.

9. A control system as claimed in claim 6 or either of claims 7 to 8 when dependent from claim 6 and including means (P1,P2,P3,P4) for adjusting:
   a) the temperature within the cabinet (2);
   b) the predetermined minimum temperature at the evaporator unit (4) at which the defrost cycle is initiated;
   c) the predetermined maximum temperature of the evaporator unit (4) at which the defrost cycle is stopped;

d) the temperature at which the fan unit (10) is switched on after termination of the defrost cycle.

Fig. 1



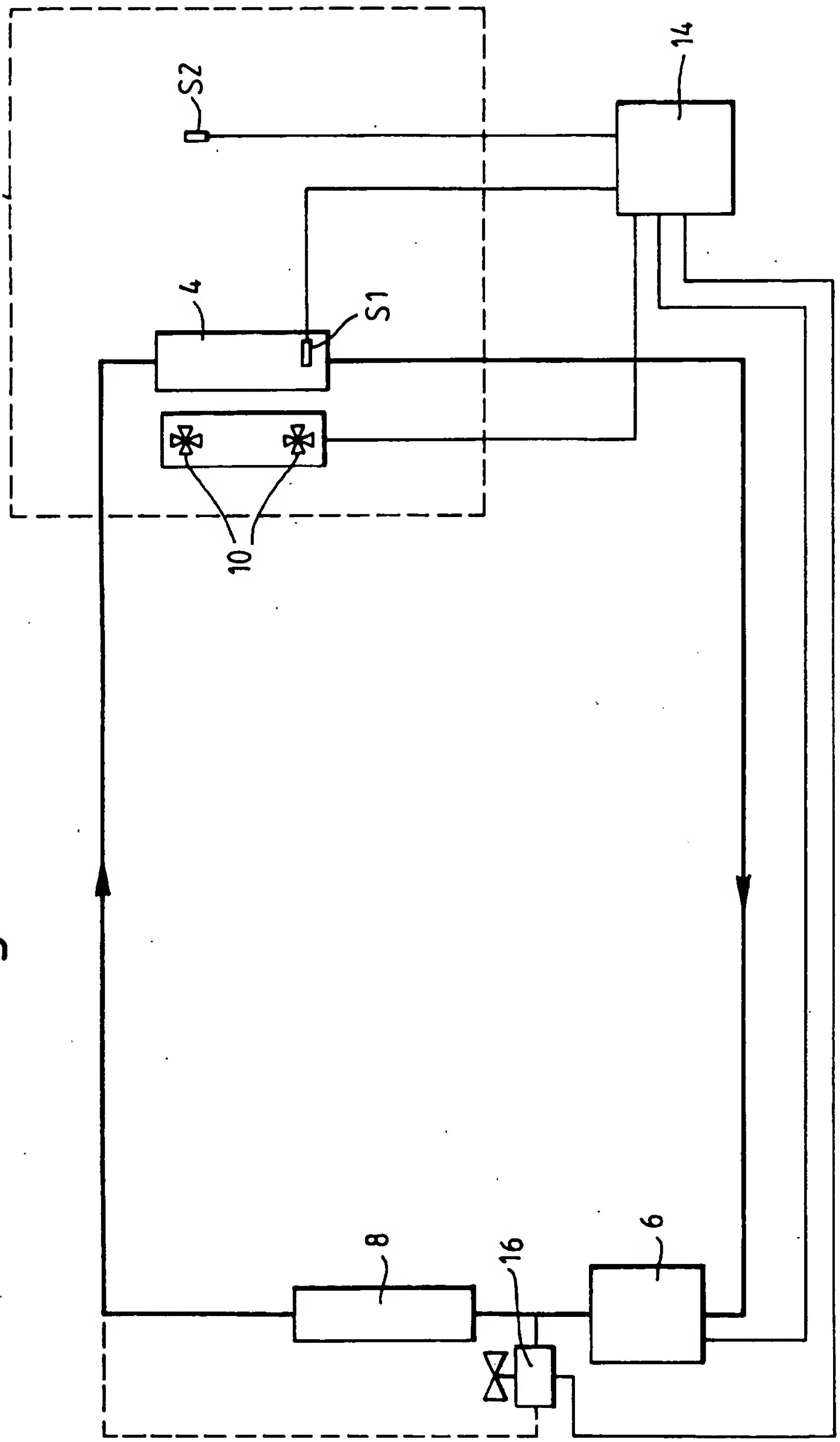
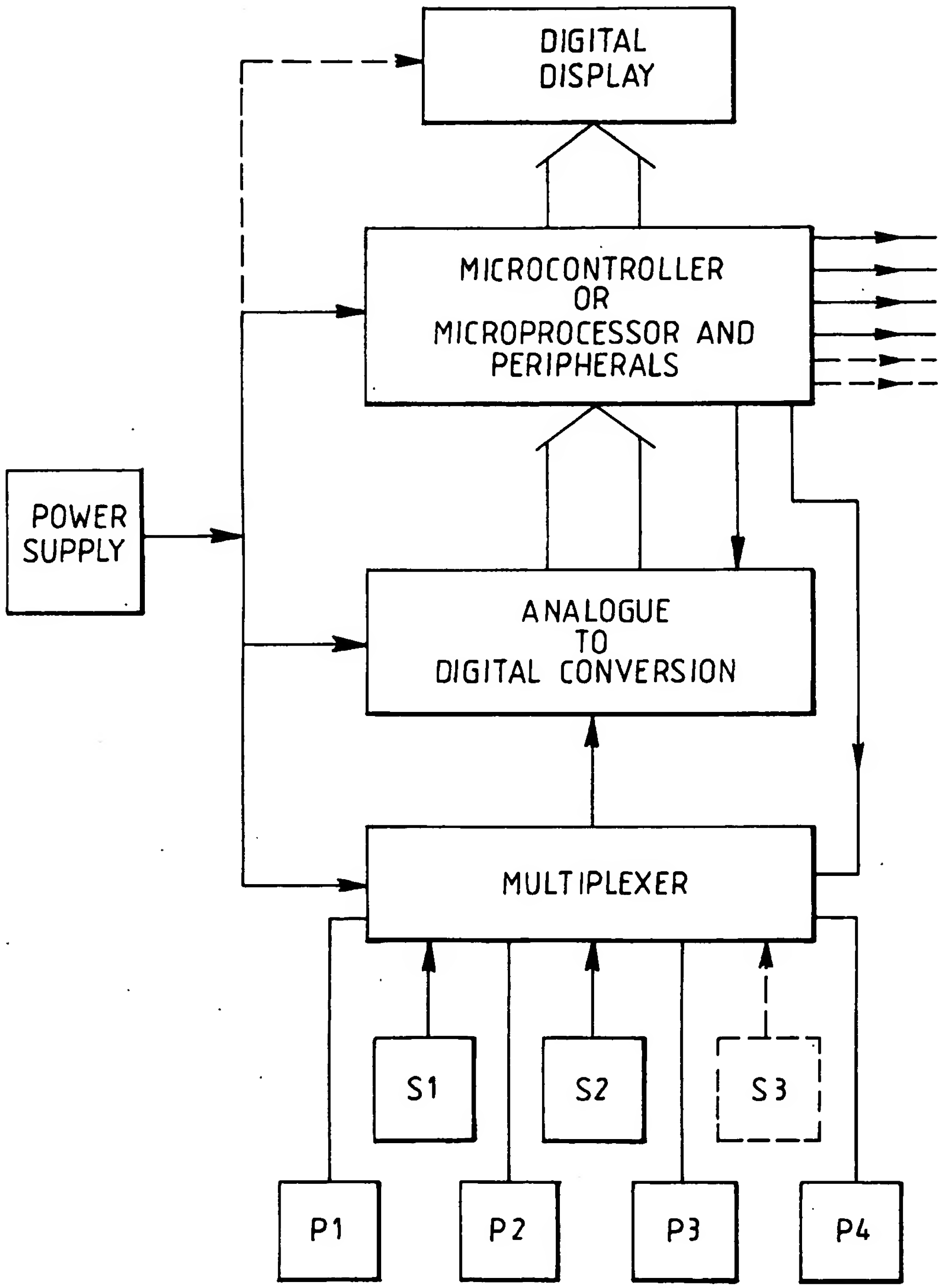


Fig. 2

Fig. 3


DIGITAL DISPLAY
MICROCONTROLLER OR MICROPROCESSOR AND PERIPHERALS
POWER SUPPLY
ANALOGUE TO DIGITAL CONVERSION
MULTIPLEXER
S1
S2
S3
P1
P2
P3
P4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 0193

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	GB-A-2 133 867 (NEWTECH CONTROLS) * abstract; page 1, line 75 - page 2, line 62; page 2, lines 98-103; page 3, lines 19-91; page 3, lines 104-130; figures 1-3; claims 1-68 * ---	1-7	F 25 D 21/06 F 25 B 47/02
X	DE-A-3 128 758 (KRÖNERT ELECTRO) * page 5, line 22 - page 6, line 2; page 9, line 1 - page 10, line 25; page 13, line 14 - page 14, line 21; figures 1-3; claims 1,2,4-6 * ---	1,2,4	
A	WO-A-8 300 211 (ALSENZ) * abstract; page 10, line 13 - page 13, line 24; page 20, line 17 - page 23, line 17; claims 1,5,10,12,16,20; figures 1,2,6 * ---	1,2,4,5,7	
A	AU-A- 459 546 (SERVEX ELECTRICAL COMPANY) * page 4, line 17 - page 7, line 14; page 8, line 19 - page 11, line 20; figures 1,2 * ---	1,2,4-7	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
A	US-A-4 663 941 (JANKE) * column 4, line 49 - column 5, line 31; column 8, lines 9-58; figures 1-4 * ---	1,2,4-7	F 25 D 21/00
A	US-A-4 750 332 (JENSKI et al.) * abstract; column 5, line 43 - column 6, line 51; column 7, line 41 - column 8, line 60; figures 2,3 * ---	1,2,4,7-9	
A	DE-A-3 227 604 (OLSBERG G.P.A.) * page 7, line 22 - page 8, line 28; page 10, lines 10-38; page 11, line 8 - page 12, line 15; figures 1,3 * -----	1-3	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	02-04-1992	BEITNER M.J.J.B.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)